Impact of High-Intensity Interval Duration on Perceived Exertion

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1School of Physical Education and Exercise Science, University of South Florida, Tampa, FL; 2School of Health and Exercise Sciences, University of British Columbia, Kelowna, BC, CANADA; 3School of Sport and Health Sciences, University of Exeter, Exeter, UNITED KINGDOM; 4Bayfront Medical Center, St. Petersburg, FL; and 5Department of Anthropology, University of South Florida, Tampa, FL

ABSTRACT
KILPATRICK, M. W., N. MARTINEZ, J. P. LITTLE, M. E. JUNG, A. M. JONES, N. W. PRICE, and D. H. LENDE. Impact of High-Intensity Interval Duration on Perceived Exertion. Med. Sci. Sports Exerc., Vol. 47, No. 5, pp. 1038–1045, 2015. Purpose: RPE is increasingly being considered as a viable tool beyond its original use for monitoring in-task exercise intensity. Research indicates that anticipated, in-task, and postexercise RPE values are often notably different from one another. An important new consideration is how perceptions are impacted by high-intensity interval training (HIT). This study aims to compare RPE responses before, during, and after continuous and HIT exercise trials. Methods: Twenty (11 females and 9 males; mean ± SD age, 22 ± 4 yr) overweight (mean ± SD body mass index, 29 ± 3 kg m⁻²) and unfit (mean ± SD VO₂peak, 28 ± 5 mL kg⁻¹ min⁻¹) participants completed a 20-min heavy continuous (HC) trial and three 24-min severe-intensity interval trials that utilized 1:1 work-to-recovery ratios: 30 s (Severe Interval-30), 60 s (Severe Interval-60), and 120 s (Severe Interval-120). Exertion was assessed using the Borg CR10 Scale. Data were analyzed using repeated-measures ANOVA and pairwise comparisons. Results: Anticipated exertion was highest in the Severe Interval-120 trial (5.8 ± 2.0; P < 0.05) compared with other trials. Exertion increased from beginning to end in all trials (P < 0.05), with the greatest increases observed within the HC trial. Session RPE for the Severe Interval-120 trial (6.4 ± 2.3) was higher than those for all other trials (P < 0.05), and session RPE for the Severe Interval-30 trial (3.7 ± 1.8) was lower than that for the HC trial (4.9 ± 1.6; P < 0.05). Conclusions: These findings suggest that 30-s HIT protocols limit the perceptual drift that occurs during exercise, in comparison to HC exercise. Moreover, performing more intervals of shorter durations appears to produce lower postexercise RPE values than performing fewer intervals of longer duration and equal intensity. Because effort perception may influence behavior, these results could have implications for the prescription of interval training in overweight sedentary adults. Key Words: EXERTION, INTERVAL, EXERCISE, PERCEPTION

The links between a physically active lifestyle and reduced risk of chronic diseases are well-established and make clear that regular exercise positively impacts markers of cardiometabolic health (8,22,34,39). These links are the basis for global physical activity recommendations suggesting participation in 150 min of moderate activity or 75 min of vigorous activity per week, with bouts at least 10 min in duration (43). These recommendations are based on a considerable volume of epidemiological and experimental evidence from continuous aerobic exercise and set the tone for public health messaging. It is notable, however, that contemporary guidelines for physical activity do not directly consider the potential utility of intermittent exercise sessions such as high-intensity interval training (HIT).

Given the increased attention that HIT has received in recent years, the need for full consideration of this form of training is warranted.

The modern approach to HIT-style exercise is traced to the training of track athletes in the middle of the 20th century (32). HIT takes many forms, but all versions incorporate repeated bursts of highly vigorous exercise interspersed with periods of recovery. Popular HIT protocols are often characterized as low-volume with respect to total work. A prominent type of HIT protocol developed more than a decade ago utilizes repeated Wingate-style exercise tests, resulting in a series of supramaximal sprints with a relatively low work-to-rest ratio (14). Repeated Wingate HIT is highly effective in promoting physiological adaptations (13), but concerns related to the tolerability of this format in general and clinical populations have been raised (9). As such, research has extended the original low-volume HIT protocol to a more practical model utilizing 10 intervals of 60 s conducted at near-maximal aerobic capacity interspersed with 60-s recoveries at very low intensities (23). Research investigating this version of HIT suggests that these protocols are both feasible and beneficial in healthy young males (24), inactive overweight adults (17), and inactive patients with type 2 diabetes (23). This body of evidence is encouraging and suggests that HIT exercise
is effective in boosting health and fitness and may be equally effective as continuous moderate exercise despite having a lower total work volume. Importantly, research to date has not adequately considered the perceptual aspects of such training.

One perceptual variable that requires greater evaluation within the context of HIT is perceived exertion. RPE was pioneered by Borg (6), who defined RPE as the degree of heaviness and strain experienced in physical work.

RPE is correlated with a variety of psychophysiological variables. Physiological variables that relate to perceptions of effort include metabolic rate, ventilation, blood flow, and muscular fatigue (6,37). Select psychological considerations that are linked to exertion include motivation, mood state, arousal, mental stress, pacing, and exercise experience (6,37,40). Importantly, RPE is considered the outcome of complex and dynamic interactions among various stimuli and inputs—perhaps best considered as a gestalt of many physiological and psychological sensations, rather than a simple summation of varied parts (6). Related conceptions of perceived exertion argue that physiological responses serve as initial mediators of intensity, which the sensory cortex then interprets as perceptual signals of exertion (37). This cognitive processing is modulated by past experiences, current context, and psychological characteristics.

Primary and original uses of RPE include measuring effort sense during graded exercise testing, as well as regulating and prescribing exercise intensity (6,37). More recent uses consider the utility of RPE assessment in the preexercise period before the onset of known exercise (19,20) and as a way of reflecting on the entire exercise session postexercise (10,11). These kinds of assessments have not yet been fully evaluated but do provide an opportunity to consider how perceptions of forthcoming and just completed effort are contextualized and linked to in-task experiences. Moreover, these assessments allow for a broader evaluation of the entire exercise experience, comparing actual in-task effort against preexercise and postexercise perceptions. Existing research in the exercise domain suggests that anticipated duration of an exercise session impacts perceived effort independent of exercise intensity (3), suggesting that effort sense is a dynamic construct that is likely to be sensitive to cognitions outside the exercise session itself. Support for this possibility is provided by research on pain expectations and pain experience, which demonstrates that expectations about painful stimuli can influence behavior (2). As such, the prospects of important interrelationships along the exercise experience time course are plausible, and potential linkages to future exercise behavior require well-designed experimental studies.

Although research has considered exertional responses to intense interval exercise sessions, studies examining intervals similar to those utilized within contemporary HIT are largely absent. Existing research on intervals of varied lengths and work-to-rest ratios provides equivocal findings related to exertional responses but do suggest that RPE responses vary by the characteristics of the interval training session. Specifically, research indicates that 6-s interval sessions produce lower RPE values than 24-s interval sessions when equated for total work and work-to-rest ratio (35). Likewise, exertional responses tend to increase over time during interval exercise trials regardless of interval intensity or rest duration despite interval segments remaining unchanged throughout the session (21,35,38,44). These findings are in agreement with research on continuous aerobic exercise indicating that anticipated length of exercise moderates RPE (36) and with related findings that experienced runners modulate attention, often using dissociative techniques, to manage exertion over longer runs (3). However, only a single study has focused on interval training protocols similar to contemporary and practical HIT (16). This study compared moderate continuous exercise and near-maximal 1-min intervals where trials were 16 min long and matched for total work. Findings generally suggested that intense intervals are perceived as more effortful near the end of the sessions and during the postexercise period than continuous trials of equal total work. Despite many important findings from the aforementioned studies, absent within each of the designs is consideration of how individuals perceive interval sessions of different lengths across the full spectrum of measurement opportunities. Evaluation of the anticipated difficulty of impending exercise and how this prediction compares against in-task and postexercise reflections on the exercise experience could prove instructive because anticipated and actual experience of HIT exercise may be very different. Such a possibility is supported by research utilizing protocols that are more continuous in nature (19,20), which show differences in perceived exertion over exercise trials. Other exercise research has found that cognitive factors, such as attentional strategies, enjoyment, pain, and anticipated running distance, can shape perceived exertion (3,4,25). Specific research examining how length of exercise impacts perceived exertion, including potential mismatches between anticipated, actual, and reflective exertion, may help better understand potential barriers to physical activity among recreational exercisers and those with very limited exercise experience.

Given the effectiveness of interval training in producing physiological benefits and the need to learn more about the likelihood that such forms of training lead to differential engagement in exercise, research investigating the perceptual aspects of interval exercise is needed. A plausible hypothesis based on theory and a limited amount of published research is that RPE will differ within and across trials of interval and continuous exercise. Therefore, the purpose of the present study is to investigate exertional responses before, during, and after exercise between one trial of heavy-intensity continuous exercise and three trials of severe-intensity interval exercise with varied interval durations in a mixed-gender sample of inactive, overweight, unfit adults.

**METHOD**

**Participants and research design.** Participants were 20 adults (11 females and 9 males; mean ± SD age, 22 ± 4 yr;
mean ± SD body mass index, 29 ± 3 kg·m⁻²) at a large university in the southeastern United States. All participants were overweight or mildly obese (body mass index, 25–35 kg·m⁻²) and not regularly active (1) but otherwise healthy. The sample size is a reflection of related research (15,19,20) and is based on an anticipated medium to large effect size (ES; i.e., 0.5–0.8), a power level of 0.8, and an α criterion of 0.05. Participants completed six trials, each separated by at least 48 h, and trials were completed over a period of 2–4 wk. The first trial was a protocol to measure peak oxygen uptake (VO₂peak). The second trial was used to familiarize participants to the forthcoming experimental trials. The remaining experimental trials included one continuous session at heavy intensity and three interval sessions of various interval lengths performed at severe intensities. All procedures were approved by the university institutional review board.

**Screening.** The first visit to the laboratory included completion of a written informed consent form, completion of a health history questionnaire, and measurement of height, body mass, resting HR, and resting blood pressure. Participants were medically screened to determine the presence of contraindications to exercise, with a specific focus on orthopedic, cardiovascular, and pulmonary conditions that would preclude participation in the research study. Participants were also instructed to avoid alcohol, caffeine, and tobacco for 3 h before testing (1).

**Metabolic testing.** A progressive ramp protocol was performed on an electronically braked cycle ergometer that maintains external workload by dynamically adjusting resistance to accommodate cadence changes (Lode, Groningen, The Netherlands). The protocol ramp rate varied between 15 and 25 W·min⁻¹ and was based on a standardized formula (42). The test was terminated when the participant could not maintain a pedal cadence of 30 rpm. HR, blood pressure, RPE, and respiratory gases were monitored in accordance with standard exercise testing guidelines (1). HR was measured using an HR monitor (Polar, Lake Success, NY), and blood pressure was determined by auscultation. RPE was estimated each minute using the Borg CR10 Scale (5).Expired gases were collected through an air cushion mask and analyzed continuously using a calibrated metabolic cart (Vacumetrics, Ventura, CA). VO₂peak was identified as the largest volume of oxygen consumed per minute during the test. Criteria for verifying maximal exertion were as follows: a peak HR of at least 90% of age-predicted maximal HR, a peak RPE of at least 9 (on a 0–10 scale), and a peak RER of at least 1.15 (30). Ventilatory threshold (VT) was identified through visual inspection of ventilatory equivalents for oxygen and carbon dioxide.

**Familiarization.** The second visit to the laboratory focused on familiarizing the research participants to laboratory procedures and experimental sessions. The objective of the familiarization trial was threefold: 1) to ensure that the workloads generated from the maximal test for the experimental trials were reasonable and appropriate; 2) to provide the participants an opportunity to experience the intensities of the forthcoming interval and continuous exercise sessions so as to ensure that the experimental trials were not entirely unfamiliar; and 3) to provide the participants an opportunity to become familiar with all experimental data collection procedures. Procedure familiarization included the use of an HR monitor and a tablet computer, which was utilized for data collection at baseline and postexercise.

**Experimental exercise trials.** The remaining visits to the laboratory included the completion of all experimental trials. The experimental trial design yielded cycle ergometer exercise sessions that fit the contemporary descriptions of exercise intensity, suggesting the presence of three intensity domains: moderate, heavy, and severe (12). Moderate intensity considers intensities up to the lactate threshold, heavy intensity spans between VT and critical power, and severe intensity considers intensities above critical power, whereby critical power is estimated to be the midpoint between VT and maximal capacity (41). Each participant completed one continuous trial within the heavy domain and three interval trials within the severe domain. Continuous and interval trials differed on total duration but were equal in terms of total external work. The continuous trial was 20 min in duration and was conducted at 10% of the distance between VT and maximal capacity (heavy continuous [HC]). The interval trials were 24 min in duration. The work portion of the three interval sessions was conducted at 60% of the distance between VT and maximal capacity, and the recovery portion was conducted at 10%–20% of maximal capacity, based on calculations designed to ensure that total work was equal for all trials. Each interval utilized a 1:1 work-to-recovery ratio and varied only in interval segment duration: 30, 60, and 120 s. The design yielded three different intervals within the severe-intensity domain: Severe Interval-30 (SI-30), Severe Interval-60 (SI-60), and Severe Interval-120 (SI-120). SI-30 included twenty-four 30-s intervals, SI-60 included twelve 60-s intervals, and SI-120 included six 120-s intervals. All work intervals were followed by recovery intervals of the same duration. All trials included a 2-min warm-up and cool-down standardized relative to peak capacity.

**Procedures.** RPE was assessed before, during, and after exercise using the single-item Borg CR10 Scale ranging from 0 to 10 (0, “nothing at all”; 3, “moderate”; 5, “hard”; 10, “very, very hard (maximal)”) (6). Instructions and anchoring procedures related to RPE assessment were standardized and based on established methodologies (37). RPE was assessed before, during, and after exercise. Preexercise RPE was taken immediately after the participant was provided a description of the upcoming trial. In-task RPE was assessed 12 times during the trials and occurred during the last 10 s of the work and recovery intervals approximating 1/6, 1/3, 1/2, 2/3, 5/6, and 6/6 of trial completion. Postexercise RPE was assessed immediately following cool-down and again 10 min later. All RPE assessments taken outside of the exercise trial were performed while the participant was seated comfortably on a reclining chair in a partitioned area adjacent to the exercise
equipment and were entered by the participant into a tablet computer. All RPE assessments taken during the exercise trial were conducted by asking the participants to report their perceptions.

Preexercise assessment asked “How much exertion do you anticipate experiencing during this trial of exercise?” and served as the prediction or anticipated RPE. In-task assessment asked “How much exertion are you feeling right now?” and served as the momentary RPE. Finally, postexercise assessment asked “How much exertion did you actually experience during this trial of exercise?” and served as the session or reflective RPE. Efforts to ensure that participants understood the RPE instructions included a description and review of the assessment procedures on the day of medical screening and maximal exercise testing. Finally, HR was assessed using an HR monitor and was recorded during collection of RPE data. As such, HR served as the objective measure of exercise intensity. Workload changes were controlled by software linked to the testing system. Interactions between research staff and participants were limited to required data collection, and members of the research staff remained largely out of view of the participants during trials. The order of experimental trials was counterbalanced.

**Statistical analysis.** Initial analyses provided descriptive characteristics of the sample and exercise trials. Next, HR responses to the experimental trials was analyzed using a series of one-way ANOVA assessing HR change over time during the exercise trials, with change representing the difference between initial and final HR values. Likewise, a separate one-way ANOVA allowed for the comparison of average (or grand mean) HR values between trials so as to evaluate the average cardiovascular response for the experimental trials. Finally, RPE responses were analyzed using a two-way ANOVA: 4 (HC, SI-30, SI-60, SI-120) × 9 (Pre, 1/6, 1/3, 1/2, 2/3, 5/6, 6/6 completion, Post-0, Post-10). A separate one-way ANOVA assessed changes in RPE during exercise and between sessions. Significant differences were followed by planned contrasts. Planned contrasts within trials compared change over time from the first to the final measurement point for work and recovery segments. Criterion for significance was set at \( P < 0.05 \). Significant differences are reported to the lowest appropriate criterion level. Mean differences were utilized to determine ES differences (0.2, small effect; 0.5, medium effect; 0.8, large effect) (7). All analyses were performed using SPSS 22 (IBM SPSS, Chicago, IL).

**RESULTS**

**Descriptive data.** Participants had a mean ± SD \( \text{VO}_2\text{peak} \) of 28 ± 5 mL·kg\(^{-1}\)·min\(^{-1}\), a mean ± SD peak workload of 199 ± 42 W, and a mean ± SD VT at 44% ± 5% of peak workload. Testing data revealed the participants had a mean ± SD maximal test HR of 188 ± 10 bpm and a mean ± SD maximal RPE of 9.8 ± 0.5, suggesting that maximal effort was achieved. Furthermore, results indicate that 95% of participants \( n = 19 \) reached the criterion for perceived effort (RPE ≥ 9), 90% of participants \( n = 18 \) reached the criterion for maximal HR (HR ≥ 90% of age-predicted maximum), and 100% of participants \( n = 20 \) reached the criterion for maximal RER (RER ≥ 1.15). Analysis of work performed during experimental trials indicates that the HC trial was performed at 50% ± 4% of peak workload, whereas work and recovery segments of the Severe Interval trials were performed at 78% ± 2% and 5% ± 4% of peak workload, respectively. Further analysis of work within the trials revealed that all trials were not different from each other in terms of estimated total caloric cost (approximately 165 kcal; \( P > 0.10 \)) and external work (approximately 691 kJ; \( P > 0.10 \)).

**HR responses.** Analysis of HR revealed significant increases during exercise for all trials \( P < 0.001 \). Approximated rate increases were as follows: 140–150 bpm for the SI-30 trial, 145–170 bpm for the SI-60 and HC trials, and 155–180 bpm for the SI-120 trial. Recovery HR increased throughout all interval trials \( P < 0.001 \), with increases of approximately 15 bpm for all trials. The grand mean HR created from all in-task and recovery HR values provided an estimate of average cardiovascular work but did not consider total cardiovascular demand because continuous and interval trials were of different total durations. These analyses revealed significant differences and a trend toward increased HR response, with increased interval length and the greatest HR response arising from the continuous trial: HC was significantly higher than all Severe Interval trials \( P < 0.05 \), SI-30 was significantly lower than SI-60 \( P < 0.05 \) and SI-120 \( P < 0.05 \), but SI-60 was not different from SI-120 \( P < 0.10 \). HR responses are reported in Figure 1.

**Perceived exertion responses.** A two-way ANOVA revealed a significant effect for time \( P < 0.001 \) and trial \( P < 0.001 \) and an interaction between time and trial \( P < 0.001 \). Follow-up one-way ANOVA and planned contrasts revealed several differences within and between trials. Predicted RPE was significantly higher in the SI-120 trial (RPE ~ 6) than in the HC and SI-60 trials (RPE ~ 5; \( P < 0.05 \);

![FIGURE 1—HR responses. *Different from beginning to end of trial \( P < 0.001 \).](Image)
ES \sim 0.5) and was nearly significantly higher than the SI-30 trial (RPE \sim 5; P < 0.10; ES \sim 0.5). Predicted RPE for all other trial comparisons were similar (P > 0.10). In-task RPE increased over time in all trials for the work phase (P < 0.001; ES range, 0.9–1.6) and the recovery phase (P < 0.05; ES \sim 0.4), except over time during recovery within the SI-120 trial (P > 0.10). The magnitude of change from the beginning to the end of the trials was approximately 1.5 units for the SI-30 and SI-60 trials (ES \sim 1.0), 2.5 units for the SI-120 trial (ES \sim 1.4), and 3 units for the HC trial (ES \sim 2.4). Session RPE measured at both postexercise time points was significantly higher in the SI-120 trial (RPE \sim 6.5) than in all other trials (RPE = 4–5; P \leq 0.05; ES range, 0.7–1.4), and the HC trial was significantly higher than the SI-30 trial (P < 0.05; ES \sim 0.7). Predicted and session RPE values were also compared and revealed no differences for HC and SI-60 trials (P > 0.10) but indicated that session RPE was significantly lower than predicted RPE for the SI-30 trial (P < 0.05; ES \sim 0.6) and predicted RPE was significantly lower than session RPE for the SI-120 trial (P < 0.05; ES \sim 0.5) immediately postexercise, but not 10 min postexercise (P > 0.05). Perceived exertion responses are reported in Table 1 and Figure 2.

**DISCUSSION**

The present investigation examined perceived exertion before, during, and after continuous and high-intensity interval exercise matched for total work among a group of inactive overweight adults. The continuous trial was 20 min in duration and was performed at 50% of peak work capacity and slightly above VT. The three intervals were 24 min in duration and were performed at about 80% of peak work capacity and slightly above critical power utilizing a 1:1 work-to-rest ratio and interval lengths of 30, 60, and 120 s. All trials were matched for total work. The experimental manipulation produced trials of exercise that fit within established exercise intensity domains and were similar to existing research protocols that are known to be highly effective in producing cardiometabolic benefits (17,23,24).

The observation within the present study that perceived exertion drifted upward over time during all trials is consistent with research designs employing HC exercise and intervals near peak work capacity (4,11,16,21). The specific details of perceptual drift are not fully understood, but two possibilities have been posited. It is possible that effort sense may be the response to sensory receptors in the periphery that detect workloads (26). Alternatively, perceptions of effort may be generated centrally by forwarding neural signals from motor areas to sensory areas of the cerebral cortex (27). Both possibilities remain plausible, but considerably more evidence supports a central origin for effort sense and suggests that exertion is significantly the conscious awareness of central motor command to working muscle (27). Importantly, the current findings indicate that perceptual drift is a function of interval segment length, in agreement with established findings within continuous exercise indicating that exertion rises during constant load work over time (18). Perceived exertion increased by approximately 1.5 units for the 30-s trial and by 2 units for the 60-s trial. In contrast, the HC and 120-s trials produced increases of about 3 units despite being equated for total work. These findings are insightful given recent research suggesting that exercise tolerance is significantly limited by perception of effort (29). As such, it seems that shorter intervals provide an exposure to highly beneficial exercise intensities while limiting perceptions of effort that are associated with muscle fatigue, which may inhibit performance and participation (28).

The factors that create differential interpretation of perceived exertion with varied interval lengths are not fully understood. Some portion of the upward drift in perceived

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Data are presented as mean ± SD RPE.
All notations indicate statistically significant differences at P < 0.05.
*Significantly different from SI-120 at preexercise.
*Significantly different from beginning to end of trial.
*Significantly different from preexercise.
*Significantly different from HC.
exertion may be attributable to physiological factors such as blood lactate accumulation and pH disturbance (35,37). However, an equal or greater consideration in exertional drift is likely linked to factors other than physiological changes. The present study observed an increase in perceived exertion for the longest interval that was approximately double the increase in the shorter interval despite no difference in total work. Prior research suggesting the importance of exercise experience, cognition, and task structure in the formation of perceived exertion (37) may also be instructive for interval-based exercise among inactive overweight participants who were not accustomed to dealing with long intervals of exercise. Although only speculative, it is possible that prior fitness and sport training experiences could impact the cognitive approach to managing the significant exertion that comes with intense exercise. Given findings in active and fit populations that attentional strategies are used to manage exertion over time (3) and that such strategies can be taught to physically active individuals (25), future research should address how attentional focus can be used to attenuate perceived exertion in less active populations.

It is also clear from the current findings that shorter intervals are perceived as requiring less effort. The HIT approach is perceived as requiring less exertion than continuous exercise, except in the longest HIT intervals of 2 min. This effect was observed even though the overall workload was the same, and this finding could be explained through at least two mechanisms. First, prior research indicates that recovery from effortful work is more than just recovery from peripheral muscle fatigue and suggests that cognitive mechanisms are as important in dealing with the discomfort associated with exertion (31). A potential influence on discomfort is that the anticipation of a long sustained interval effort can be perceived as more aversive. Research on dread has shown that some individuals prefer receiving painful stimuli sooner rather than waiting in anticipation of a less painful stimuli (5). This limited research therefore points to the possibility that “getting it out of the way” might be an important cognitive advantage of shorter HIT approaches. That is, the opportunity to more quickly work through potentially noxious stimuli, such as muscular fatigue and dyspnea, may be preferable to the anticipation of a much longer exposure to the same stimulus. Second, inserting periods of recovery in between high-intensity interval segments allows for a break from both the physical and the cognitive demands associated with intense exercise. Limiting cognitive demands in this manner may be important given research demonstrating that mental stress increases perceptions of effort and reduces endurance performance (27,33). Likewise, these frequent breaks from severe intensities might contribute to lesser increases in perceived effort during shorter intervals. As such, “catching one’s breath” might make it cognitively easier to maintain interval work over time.

The present data provide some support for both mechanisms as contributing to exertional differences. RPE in the 30-s trial starts near a 3 rating and rises to about 4.5, for an overall increase of 1.5 units. In contrast, RPE in the 120-s trial starts near 4 and ends near 7, with an overall increase of almost 3 units. As such, the average first rating is lower in shorter intervals than in longer intervals, pointing to

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**FIGURE 2—Perceived exertion responses.** *Different from beginning to end of trial (P < 0.001 for work; P < 0.05 for recovery). **Different from preexercise (P < 0.05).*
anticipatory effects. Separately, the much smaller increase in RPE for the shorter interval highlights that frequent breaks seem to blunt the upward drift of RPE over time, which connects with the idea that shorter intervals provide more opportunities for recovery between periods of extreme work. It is possible that the shorter intervals were perceived as less effortful in part because shorter bursts may have attenuated the disruption of physiological homeostasis. Future research should aim to delineate the respective contributions of these two different mechanisms by which length of intervals can affect ratings of perceived effort. Likewise, the demonstration of intervals no greater than 60 s points to the need for future research to determine how cardiometabolic benefits may differ between HIT protocols of differing interval lengths.

Limitations to the current study design include considerations related to the sample, laboratory-based research design, and absence of measures that link to future exercise behavior. Concerns related to the sample focus primarily on age, but a larger sample would have also allowed for consideration of potential moderators such as gender and weight status. Although the sample targeted a desirable demographic of unfit and overweight adults, the participants were young and mostly college students, limiting generalizability. Likewise, the design allowed for careful laboratory manipulation of important research variables; however, the resulting exercise sessions lack significant ecological validity but are representative of common approaches to exercise. Another laboratory-related limitation is that the findings do not include metabolic markers of exercise intensity or potentially valuable measures of fatigue and affect. A final significant limitation relates to the absence of design features that would provide insights into the likelihood that the trials would be repeated for exercise intention and self-efficacy, both of which are important within the context of maintenance of exercise behavior. Collectively, these limitations suggest that future research in this area should consider these issues when developing research designs. Likewise, research investigating the implications for differential exertion before, during, and after exercise would be useful in designing effective exercise interventions.

In summary, the current design evaluates how a sample of unfit and overweight adults perceive high-intensity interval exercise and continuous exercise matched for total work. Findings from this study indicate that anticipated exertion, exertion experienced during exercise, and reflections on just completed effort are not always well-matched. Although perceptions of effort for 60-s intervals in the latter minutes of the session tended to match that which was anticipated and experienced upon recovery, intervals of only 30 s tend to be less effortful than anticipated, and intervals of 120 s are considerably harder than expected. Although each session required the same amount of total work, these results point toward the possibility that intervals of similar relative intensity not exceeding 60 s may be preferable if the goal of exercise is to produce significant cardiometabolic stress while minimizing exposure to perceptions of exertion being less effortful, especially in individuals not accustomed to the physical sensations associated with intense exercise. The novel assessments of anticipated and reflective exertion utilized in the current study provide insights on comfort level associated with the exercise experience. Fitness professionals and clinicians are often required to make modifications to exercise prescriptions based on physiological responses to exercise, and the current findings indicate that perceptual aspects of the exercise experience may need to be considered alongside more objective indicators of actual workout intensity. These results, although preliminary, suggest that shorter HIT intervals are more palatable than longer intervals for novice exercisers, and that maintenance of relatively modest levels of perceived exertion throughout the entire exercise experience may be advisable to encourage sustained exercise behavior.

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